Italian Botanist 7: 1–16 (2019)
doi: 10.3897/italianbotanist.7.31727
http://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

The occurrence of *Brassica montana* Pourr. (Brassicaceae) in the Italian regions of Emilia-Romagna and Marche, and in the Republic of San Marino

Lorenzo Maggioni[1], Alessandro Alessandrini[2]

1 *Bioversity International, Via dei Tre Denari, 472/a, 00057 Maccarese (Roma), Italy* **2** *Istituto Beni Culturali, Regione Emilia-Romagna, Bologna, Italy*

Corresponding author: *Lorenzo Maggioni* (l.maggioni@cgiar.org)

Academic editor: *F. Bartolucci* | Received 17 November 2018 | Accepted 21 February 2019 | Published 7 March 2019

Citation: Maggioni L, Alessandrini A (2019) The occurrence of *Brassica montana* Pourr. (Brassicaceae) in the Italian regions of Emilia-Romagna and Marche, and in the Republic of San Marino. Italian Botanist 7: 1–16. https://doi.org/10.3897/italianbotanist.7.31727

Abstract

Brassica montana Pourr., a wild relative of the *Brassica oleracea* L. cole crops (broccoli, cabbage, cauliflower, etc.), deserves special attention for its potential to easily transfer agronomically useful traits to related crops. Monitoring existing *B. montana* populations is the first step to enabling long-term conservation and management of wild genetic resources. The main distribution area of *B. montana* extends along the coasts of the northern Mediterranean Sea from north-east Spain to north-west Italy (coast of Liguria and Apuan Alps in Tuscany). Further east and south, the distribution of *B. montana* is fragmentary, with isolated populations, in some cases, only observed in the 19th or early 20th century and never re-confirmed later. In this paper, we focus on all the *B. montana* reports for the Italian regions of Emilia-Romagna and Marche, and additionally for the neighbouring Republic of San Marino. Literature records were verified through field visits where possible. According to our analysis, the presence of *B. montana* is confirmed in the Marche and the Republic of San Marino, but not in Emilia-Romagna. We recommend further studies on the distribution of *B. montana* in Italy, also applying molecular means, beyond morphology, to distinguish *B. montana* from naturalized *B. oleracea* and other related taxa.

Keywords

Brassica montana, Northern Apennine, crop wild relatives

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Introduction

Brassica montana Pourr. (Brassicaceae), belongs to *B.* sect. *Brassica*, which includes the taxa sharing the same C genome ($x = 9$) with the *B. oleracea* L. cole crops, as proposed by Stork et al. (1980) and elaborated by Snogerup et al. (1990). This genetically coherent group includes mainly Mediterranean chasmophytic suffrutescent species, which are highly interfertile and correspond to the *B. oleracea* primary genepool (Harlan and de Wet 1971). Together with *B. montana*, the section (also called "*Brassica oleracea* group") is represented in the Italian flora by the following species (Bartolucci et al. 2018): *B. rupestris* Raf. (with two subspecies), *B. incana* Ten., *B. villosa* Biv. (with five subspecies), *B. macrocarpa* Guss., *B. insularis* Moris, *B. thyrrena* Giotta, Piccitto & Arrigoni, and *B. trichocarpa* C.Brullo, Brullo, Giusso & Ilardi. All these taxa may be used as genetic resources, potentially hosting valuable traits that could be transferred to the respective cultivated crops (cabbage, cauliflower, broccoli, etc.). For example, drought and insect tolerance and high glucosinolate content, which have been recorded for *B. montana*, are traits of potential agronomic value (Warwick et al. 2009, Pelgrom et al. 2015). Particular attention should be dedicated to the knowledge of taxa with economic potential. Knowledge about distribution and status of their populations (i.e. size, level of threat, etc.) is the primary information for their conservation and possible use.

Brassica montana is distributed along the coasts of the northern Mediterranean Sea from north-eastern Spain to south-western Italy. In Italy, *B. montana* is more common along the coast of the Liguria region, in inland localities in the Apuan Alps (Tuscany) and on the Pontine Islands (Lazio). A localized presence has also been reported further east in Emilia-Romagna and Marche, the Republic of San Marino, as well as further south in Campania, Basilicata and Calabria regions (Biondi et al. 2002a, Bartolucci et al. 2018) (Figure 1). According to Biondi et al. (2012), the fragmentary distribution in Italy has a relic origin. Other authors discuss the identity of some populations, which they assume to have escaped from cultivation, such as in the area of Monte Conero (Marche) (Snogerup et al. 1990). Difficulties about the taxonomic identity of some populations were also pointed out by Anzalone and Caputo (1974–1975: 35–36) for the Pontine Islands, because of a possible confusion between *B. montana* and hairless individuals of *B. incana*.

This paper examines previous reports of *B. montana* for the most eastern part of its native range. This is intended as a contribution towards a complete inventory of all the Italian populations of *B. montana*. The most accurate and thorough study about the native range of *B. montana* (Snogerup et al. 1990) in fact, only summarily treated the eastern localities, without any mention of populations in southern Italy. According to the present study, *B. montana* is not confirmed in Emilia-Romagna, while it currently grows in the Marche and the Republic of San Marino.

Materials and methods

Available sources of information indicating the distribution of *B. montana* in Emilia-Romagna, Marche and San Marino were analysed, based on existing bibliography,

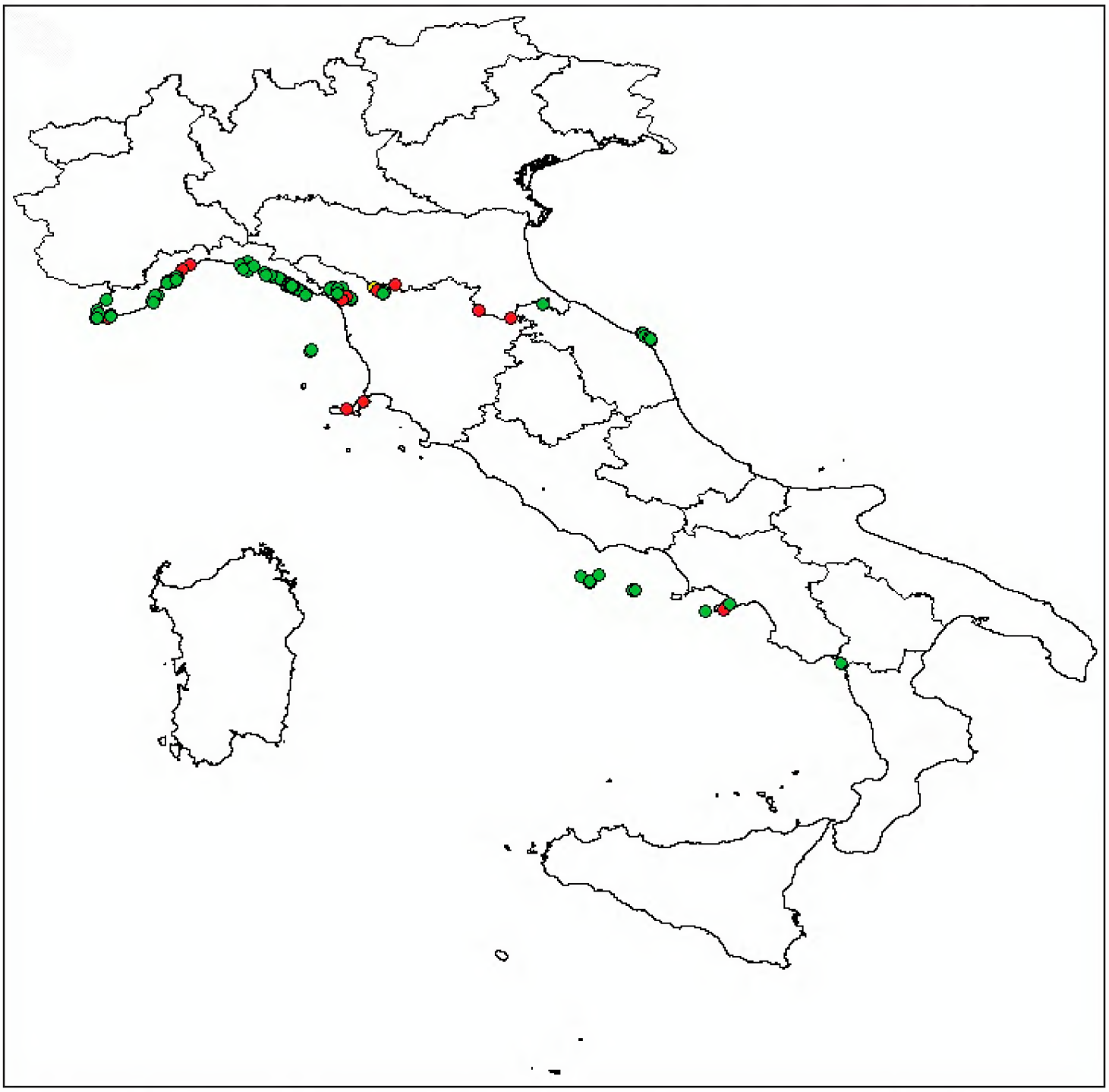

Figure 1. Distribution of *B. montana* in Italy, based on available public sources. For Liguria, among others, Wikiplantbase #Liguria, Barberis et al. (2016 onwards). For Tuscany, among others, Peruzzi and Bedini (2015 onwards). Green dots: records post 1950; red dots: records before 1950.

online resources such as the anArchive System (http://www.anarchive.it/anArchive), herbarium specimens and personal field observations. Herbarium material was directly consulted at FI, RO, and VER. Information from other herbaria (AQUI, BOLO, CAME, G, GE, MOD, NAP, PAV, SIENA, and TO) (herbarium acronyms follow Thiers 2019) was obtained from the Internet or via email exchange with the respective curators. The following names have been regarded as synonyms of *B. montana*, following Marhold (2011): *B. robertiana* J.Gay and *B. oleracea* subsp. *pourretii* Foucaud & Rouy. Other combinations based on *B. oleracea* var. *sylvestris* L. and used by Italian authors (e.g., Paoletti 1896) are synonyms of *B. oleracea* L. subsp. *oleracea* (Marhold 2011). The latter taxon is regarded as native to the Atlantic coasts of northern Spain, France, the British Isles and Helgoland (Germany) (Snogerup et al. 1990).

Results

Our survey of available resources identified seven localities where the presence of *B. montana* has been reported: four in Emilia-Romagna, two in the Marche and one in the Republic of San Marino. Information collected for each of these localities is described below.

Emilia-Romagna

Province of Modena

1. Lago Naro: the presence of *B. montana* has been recorded in the flora of the Modena province (Alessandrini et al. 2010) on just one site "*sopra al lago Naro nella valle del Baccio*" [above lake Naro, in the Baccio valley]. This locality, at about 1500 m a.s.l., is very close to the mountain ridge overlooking Tuscany. Repeated searches for living populations were made in this locality by Maggioni in August 2016 and April 2017, without success. It was not possible either to track down original herbarium specimens or photographic evidence on the first sighting of this population.

Province of Bologna

2. Riva di Dardagna: this locality was mentioned in a note by Cavara (1890), who described a perennial wild brassica originally found several years before by his friend Rodolfo Farneti and then collected together with Farneti in July 1885 (Figure 2). The sample was identified as a new variety, *Brassica robertiana* var. *apenninica* Cavara, owing to differences in leaf shape, siliqua shape and seed colour, compared to the description of *B. robertiana* included in contemporary floras of France (Grenier and Godron 1848: 79) and Spain (Willkomm and Lange 1861–1880: 858). The site is described as located in the upper Bologna Apennine at around 800 m a.s.l. The upper valley of the river Dardagna is close to the border between Emilia and Tuscany. The exact location, indicated as *Balza de' Coli* cliff, is impossible to pinpoint on a map. Several attempts to find remnant populations in this area were made in recent years without success. The so-called Riva (this name indicates a rocky slope) was observed by Alessandrini in 2014 to be steep and unstable, with frequent rock landslides, which might be the cause of the ancient population's extinction. In PAV, temporarily not accessible for consultation, five sheets have been found with specimens from the site in the Province of Bologna sub "*B. robertiana* Gay var. *appenninica* (sic!) Cavara"; the most precise indication of the place of discovery is: "*Alto appennino Bolognese nella Riva del Dardagna presso Ca' d'Julio in luogo detto balzo dei Pianacci e Balzo dei Coli*. 1887-8". In G two samples collected

Figure 2. Illustration of *Brassica robertiana* var. *apenninica*, from Cavara (1890), courtesy of Biblioteca Dipartimento BiGeA – Alma Mater Studiorum – Università degli Studi di Bologna. Photo credit: A. Alessandrini.

Bearbeitet für das „Pflanzenreich".
Brassica montana Pourret
var. apennina (Cavara) O. E. Schulz
det. O. E. Schulz
1915.
Brassica sp.
Riva di Vardagna - Apennino bolognese
Es. in fiore Maggio 1888
Es. in frutto Luglio 1886
Dr. F. Cavara & R. Farneti
Type material of B. robertiana Gay
var. apennina Cavara
Probably = B. montana Pourr., but mate-
Det. Sven Snogerup 1988 rial insufficient
leg. Dr. Cavara et R. Farneti
HERBIER BARBEY-BOISSIER
Constitué par William Barbey, après la mort de son beau-père Edmond Boissier (1885); donné en 1918, par les enfants de W. Barbey, à l'Université de Genève où il fut augmenté par différents collaborateurs; transféré en 1944 au Conservatoire botanique.

Figure 3. Type material (stated by S. Snogerup) of *Brassica robertiana* var. *apenninica* Cavara at G. Photo credit: Conservatoire et Jardin botaniques de la Ville de Genève.

by Cavara and Farneti between 1886–88 are preserved (barcode: G00426761 and G00426761_a), cited by Snogerup et al. (1990) from the same site; a label added by S. Snogerup (dated 1988) states that it is the "Type material of *B. robertiana* Gay var. *apenninica* Cavara" and that this is "Probably = *B. montana* Pourr., but material insufficient" (Figure 3).

Province of Forli-Cesena

The card index of the Zangheri's herbarium, deposited at VER, reports two specimens under *B. oleracea* L. subsp. *silvestris* L. (Mill.), found at the following two localities:

3. Balze: this place, currently called Balze di Verghereto (or Le Balze), is located at 1090 m a.s.l., on the border between Romagna and Tuscany. The herbarium specimen (collection number 4623) was collected by Zangheri in a rocky habitat (*rupi*) on 26 July 1923. The tag shows (Figure 4) that the specimen was determined by Béguinot. An anonymous note (in Italian), possibly written by Zangheri himself or by a subsequent reviewer, raises some doubts about the identification: "*Da raccogliere con frutti ben maturi ed allora si potrà [precisare?] meglio la determinazione!*" [to be collected with well mature fruits, so that the determination can be more accurate]. A survey of the cliffs at Le Balze was carried out by Maggioni in August 2016, but no wild brassicas were found.
4. Campigna: locality above 1000 m a.s.l., in the Bidente Valley, within the National Park of Casentino Forests, Monte Falterona and Campigna, at the border between Romagna and Tuscany. This specimen was collected by Zangheri in a rocky habitat (*rupi*) on 1 July 1924 (collection number 4622). The sample no longer exists and a note in the card index written by Zangheri himself (Salmaso, pers. comm. 2017) indicates that it was eliminated (Figure 5). An online portal of the flora of the National Park of Casentino Forests, Monte Falterona and Campigna (http://dryades.units.it/casentinesi/, accessed 30 June 2018) indicates that the species' presence in the park needs confirmation. This is in line with the findings of Viciani (2011).

Republic of San Marino

5. Monte Titano: Two samples collected at Monte Titano by Pampanini (sub "*B. oleracea* L. var. *silvestris* L. Mill.") in June 1912 ("San Marino, *sulle rupi calcaree*" [on the calcareous rocks]) and in May 1929 ("M. Titano, *vers. or.*" [eastern slope]) are conserved respectively at FI and VER (Figure 6).

When Snogerup et al. (1990) examined the specimen from FI they considered it of dubious identity, on account of its very broad, short-petiolate leaves. Biondi and Vagge (2004) also reported *B. oleracea* subsp. *robertiana* (= *B. montana*) for Monte Titano:

Figure 4. Herbarium specimen N. 4623, locality Balze, Zangheri collection, VER.

"M. Titano (*sotto il castello* [below the castle]), 19 May 1994" and "Borgo Maggiore, 26 June 1998" and found "on the limited vertical positions of the calcareous cliffs that are exposed to northeast". Possibly the same location of previous observations, pre-

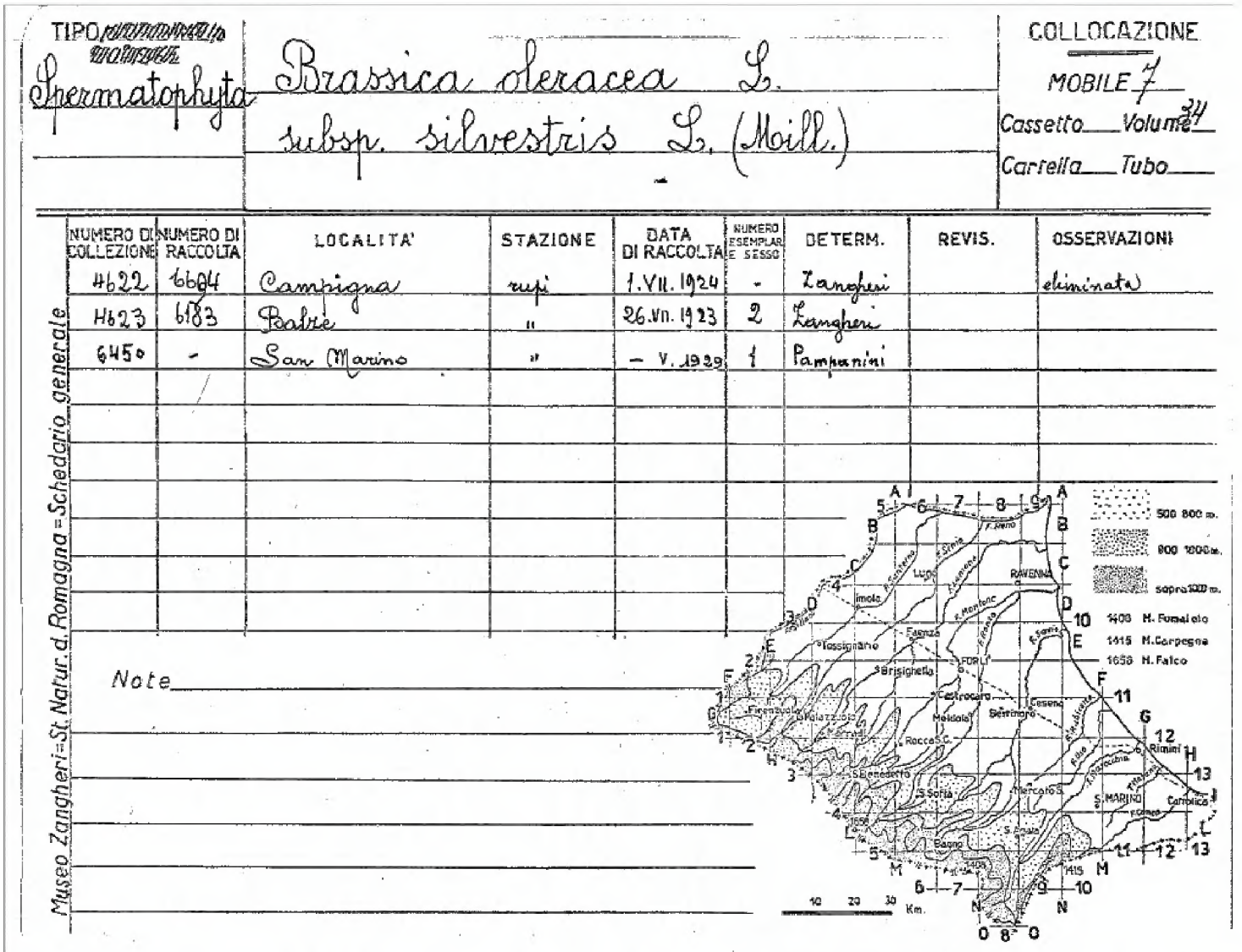

Figure 5. Card index for "*Brassica oleracea* L. subsp. *silvestris* L. (Mill.)" from the Zangheri collection, Museo Civico di Storia Naturale, Verona, Italy.

cisely on the rocky slope along the road Strada Sottomontana in Borgo Maggiore, east slope of M. Titano, at ca. 550 m a.s.l., was monitored by Maggioni in August 2014. The population of ca. 50 individuals shows the typical habit of *B. montana*; however, some individuals show very broad leaves and sometimes a glaucous and waxy leaf surface, which are typical of cultivated crops (Figure 7).

Marche

Province of Ancona

6. Monte Conero: *B. montana* is common in the Conero Regional Nature Park, where it is mainly included, according to Biondi et al. (2012) in the two vegetation communities described below. The halo-rupiculous *Reichardio maritimae-Brassicetum robertianae* Biondi 1982 develops in rocky crevices of the calcareous walls. In most elevated sectors of rocky walls, it is possible to find the "*Brassica montana* and *Matthiola incana* Community", both in marly-arenaceous and in most elevated stretch-

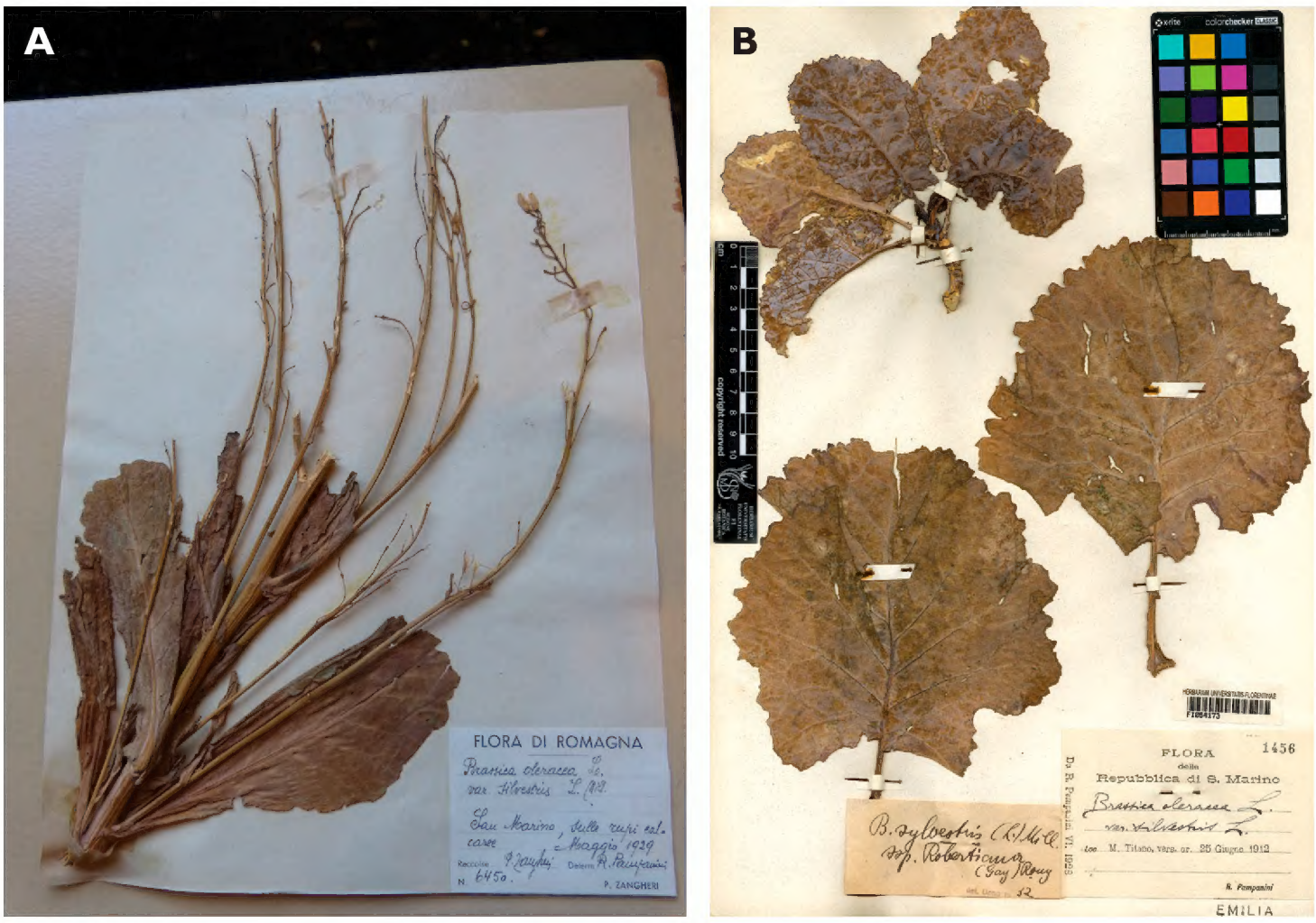

Figure 6. Herbarium specimens collected by Pampanini in San Marino. Courtesy of Museo Civico di Storia Naturale, Verona (left) and of Museo di Storia Naturale, Florence (Italy) (right).

es of calcareous cliffs (Biondi et al. 2012). Overall, *B. montana* colonizes the coastal cliffs from Monte dei Corvi southwards up to the Sassi Neri beach (Biondi et al. 2000). Records available from the online source anArchive (http://www.anarchive.it/anArchive/) list specific sites where the taxon has been observed or collected: Passo della Croce (herbarium specimen from Brilli-Cattarini, CAME#230, 1965); valley in front of Scoglio delle Due Sorelle, Portonovo; Scoglio della Vela; Spiaggia dei Gabbiani, Sirolo and Spiaggia Sassi Neri under Passo del Lupo (Biondi 1986); Scoglio del Libro and Valle delle Vellare (Biondi et al. 2002b). Maggioni also recorded the presence of a large population along the trail on both sides of Passo del Lupo (also called Passo della Croce) (Figure 8) in 2005. The oldest herbarium specimen known to us for the Monte Conero area, collected at Scogli degli Schiavi, is conserved at FI, where it was received from Narducci in July 1856. This sample was classified by Onno in 1932 as *B. sylvestris* (L.) Miller subsp. *robertiana* (Gay) Rouy.

7. Ancona: The presence of a population in Ancona was mentioned by Landucci et al. (2014), who reported it as a new finding made in 2012. However, several herbarium specimens collected in Ancona, possibly in the same locality, date back to 1876 (*Ricci*, FI), 1880 (*Costa Righini*, PI) and 1890 (*Narducci et Profili*, FI), as reported by Onno (1933). This population, visited by Maggioni in May 2017, consisted of no less than 200 individuals growing on the steep cliffs delimiting the

Figure 7. *Brassica montana*, Borgo Maggiore, San Marino, August 2014. Bottom right image shows glaucous and waxy leaves. Photo credit: L. Maggioni/Bioversity International.

narrow beach called Passetto, both north and south of the war memorial. Many plants could also be found among the walls of the fishermen's boat shelters in front of the beach (Figure 9). This population probably forms a continuum with the Monte Conero populations described above, as the cliffs' habitat extends in that direction without major interruptions. This locality is also included within the borders of the Conero Regional Nature Park.

Regarding the presence of *B. montana* in the Marche, it should be noted that Snogerup et al. (1990) mentioned that "a locality S of Ancona given by Onno (1933) refers to a population of escaped *B. oleracea*". Paolucci (1890) also considered this taxon, extensively growing on coastal cliffs between Ancona and M. Conero, to belong to *B. oleracea*. He specified that the broccoli, cauliflowers and cabbages were grown everywhere in gardens and fields. Based on the taxonomic key of Snogerup et al. (1990), we identified the populations of Monte Conero and Ancona as *B. montana*. The likely presence of cultivated plants escaped from gardens and/or situations of hybridization between cultivated and wild specimens are the probable reasons for different interpretations in the past.

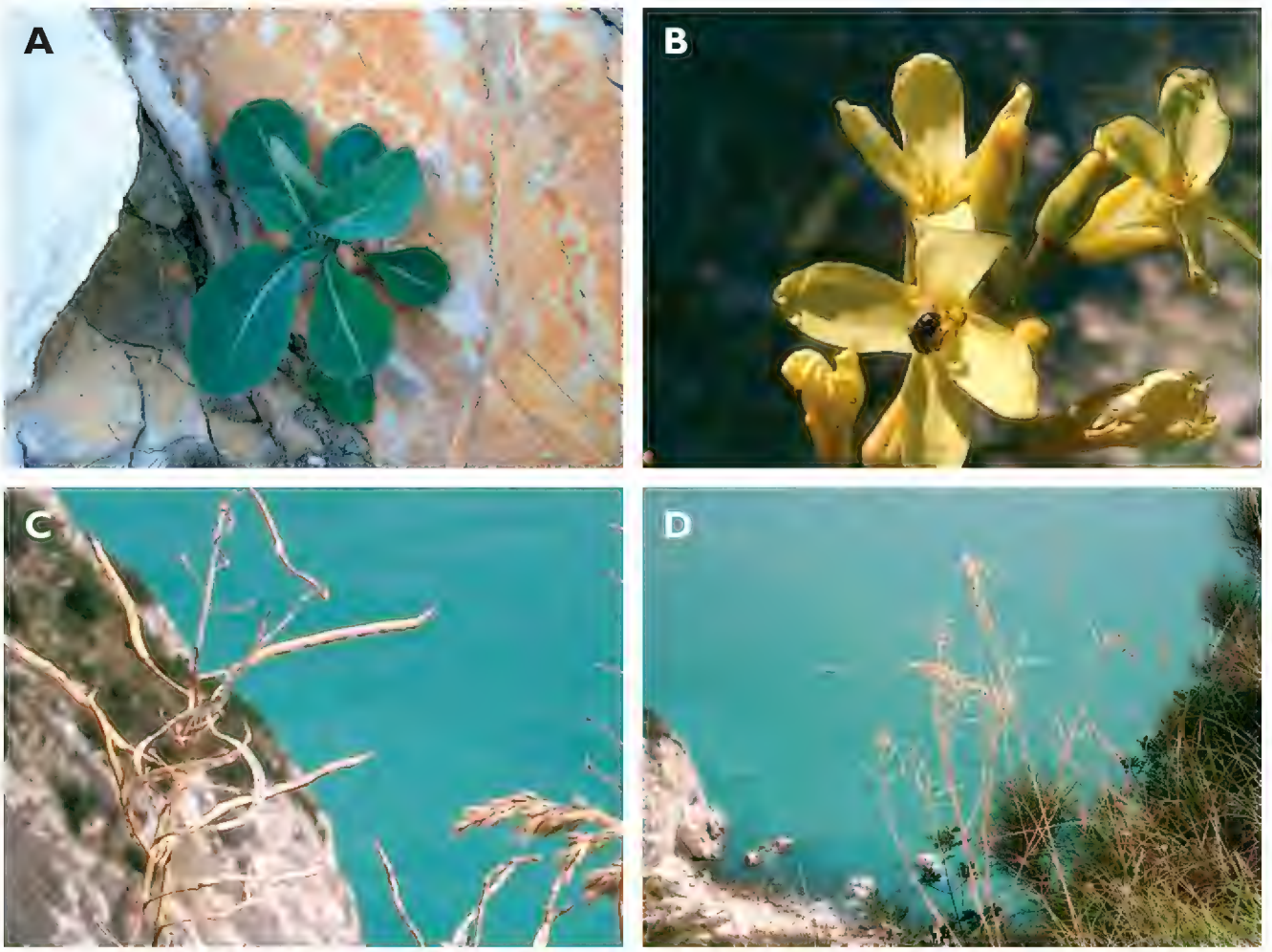

Figure 8. *Brassica montana* near Passo del Lupo, Monte Conero, May (left) and August (right) 2005. Photo credit: L. Maggioni/Bioversity International.

Figure 9. *Brassica montana*, il Passetto, Ancona, May 2017. Photo credit: L. Maggioni/Bioversity International.

Discussion

The presence of *B. montana* in Emilia-Romagna has not been confirmed by our research. The only recent observation of *B. montana* in this region refers to the Modena province (Lago Naro) and dates back to 2005. However, the species is no longer present here. Previous observations in other localities in the region were made between 1885 and 1923. It should also be noted that the only herbarium specimens we traced from Emilia-Romagna were collected at Le Balze in 1923 (*Zangheri*, VER) and at Riva di Dardagna in 1886–1888 (*Cavara et Farneti*, G and PAV), in both cases of uncertain identification. The illustrations and descriptions from Cavara (1890) of the individuals found in the Bologna province (Riva di Dardagna) are very detailed, but Cavara himself expressed several doubts about their identification with *B. montana*. He also took into consideration the hypothesis of a naturalization from ancient gardens, even though unlikely in his opinion, given the distance between the inaccessible cliffs where the plant was thriving and any ancient human settlement.

The eastern populations were known at least since 1856 in the case of Monte Conero (*Narducci*, FI), 1876 (Ancona) (*Ricci*, FI), and 1912 (San Marino) (*Pampanini*, FI). They have been repeatedly confirmed until now. It is noteworthy that from time to time various authors (Paolucci 1890, Onno 1933, Snogerup et al. 1990) regarded these populations as possibly originated from escaped individuals of *B. oleracea*. The possible reversion of escaped populations, becoming morphologically indistinguishable from wild plants within a few years, was discussed, among others, by Mitchell (1976) and Maggioni (2015). The discrimination between naturalized populations of *B. oleracea* and *B. montana* is mainly based on the colour of the leaves (greyish-glaucous in *B. oleracea*, slightly greyish, pure to bluish green in *B. montana*) (Snogerup et al. 1990). The ease with which any taxon belonging to the section can intercross with cultivated types also adds a further element of complication. A definitive clarification of the taxonomic status of the *Brassica* populations considered in this study will probably require accurate analysis, also at the molecular level, and a comparison with populations of *B. montana* group from its entire range.

On the other hand, if we assume that all the populations observed in the Northern Apennines truly belong to *B. montana*, an interesting pattern is drawn (Figure 10). In fact, the corresponding localities approximately follow the Northern Apennine ridgeline along the boundary between Tuscany and Emilia-Romagna, from the Apuan Alps in the west and eastwards to Monte Titano and Monte Conero. This pattern is in line with the statement by Biondi et al. (2012) that *B. montana* "...presents a fragmentary range of distribution having a relic origin". The fragmentary pattern also extends southwards, with the well-known populations on the Pontine Islands (Anzalone and Caputo 1974–1975), while confirmation of other isolated localities further south would require further investigation according to the authors.

An alternative explanation for the fragmentary distribution of *B. montana* at its eastern edge is a long-distance dissemination from the Apuan Alps populations. In this case, only few individuals might have occasionally overstepped the Apennine ridge to Emilia-Romagna, finding a favourable habitat only along the Adriatic coast.

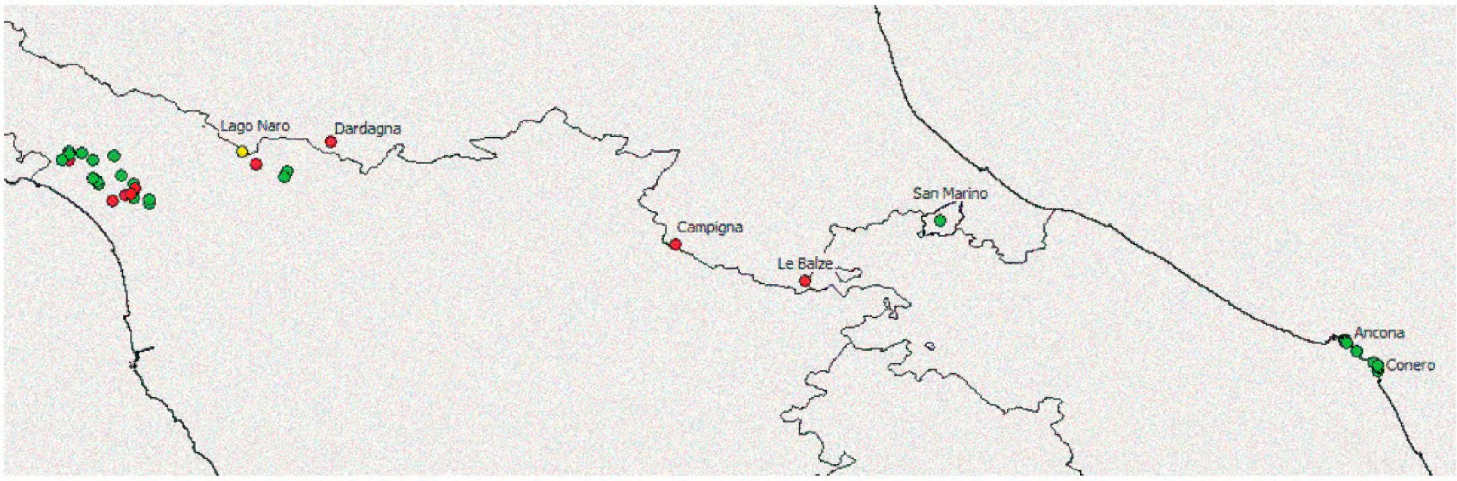

Figure 10. Distribution of *Brassica montana* in the Northern Apennine, based on available public sources. For Tuscany, among others, Peruzzi and Bedini (2015 onwards). Green dots: records post 1950; red dots: records before 1950; yellow dot: recent observation, not confirmed by the present paper.

Conclusion

The current presence of *B. montana* in Emilia-Romagna cannot be confirmed, while populations of *B. montana* are thriving well in the province of Ancona and the Republic of San Marino. The full distribution range of *B. montana* in Italy needs to be further investigated, possibly following a careful identification, based on both morphological traits and molecular means.

Acknowledgments

The authors wish to acknowledge precious help and availability of Annalisa Managlia (BOLO), Chiara Nepi and Lorenzo Cecchi (FI), Laurence Loze and Laurent Gautier (G), Annalisa Santangelo (NAP), Nicola Ardenghi (PAV), Maurizio Pierfranceschi (RO), Francesco Di Carlo (VER), and Claudia Bonfiglioli (Biblioteca Erbario e Orto Botanico, Università di Bologna). We thank Elinor Lipman and Olga Spellman (Bioversity International) for English and copy editing. Finally, we thank two anonymous reviewers for critically reviewing the manuscript and suggesting substantial improvements.

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